Managing Bond Portfolios

11

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11.1 Interest Rate Risk

- Interest Rate Sensitivity

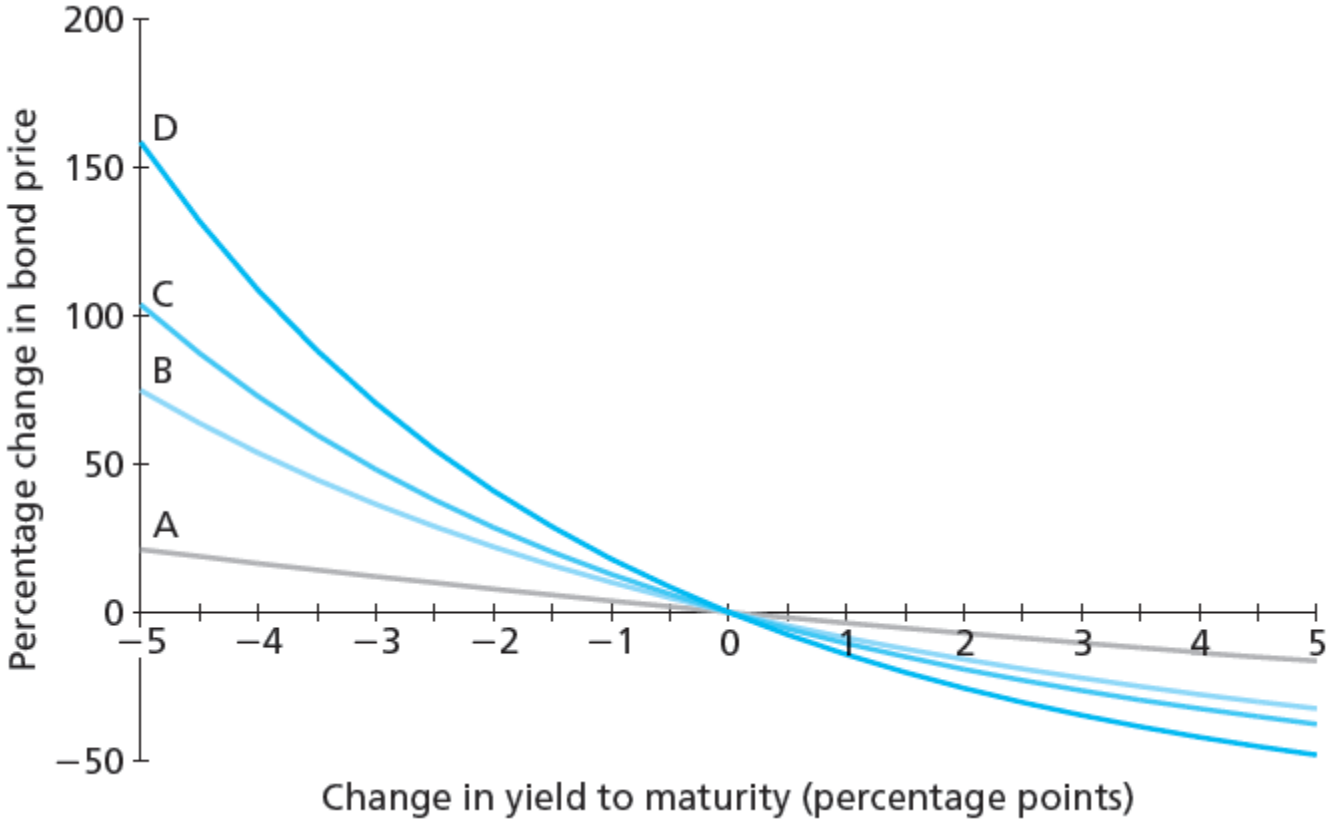
Bond theorems

  - Bond prices and yields are inversely related
  - Increase in bond's yield to maturity results in smaller price change than yield decrease of equal magnitude
  - Long-term bond prices more sensitive to interest rate changes than short-term bonds
  - As maturity increases, sensitivity of bond prices to changes in yields increases at decreasing rate

11.1 Interest Rate Risk

- Interest Rate Sensitivity
  - As maturity increases, sensitivity of bond prices to changes in yields increases at decreasing rate
  - Interest rate risk is inversely related to bond's coupon rate; low-coupon bonds are more sensitive to interest rates
  - Sensitivity of bond's price-to-yield change is inversely related to current yield to maturity

Figure 11.1 Change in Bond Prices as a Function of Change in Yield to Maturity



Bond	Coupon	Maturity	Initial YTM
A	12%	5 years	10%
B	12	30	10
C	3	30	10
D	3	30	6

Table 11.1 Annual Coupon Prices

Prices of 8% annual coupon bonds

Bond's Yield to Maturity	*T* = 1 *Year*	*T* = 10 *Years*	*T* = 20 *Years*
8%	1,000.00	1,000.00	1,000.00
9%	990.83	935.82	908.71
Percent change in price*	−0.92%	−6.42%	−9.13%

*Equals value of bond at a 9% yield to maturity minus value of bond at (the original) 8% yield, divided by the value at 8% yield.

Table 11.2 Zero-Coupon Bond Prices

Prices of zero-coupon bonds			
Bond's Yield to Maturity	***T* = 1 *Year***	***T* = 10 *Years***	***T* = 20 *Years***
8%	925.93	463.19	214.55
9%	917.43	422.41	178.43
Percent change in price*	−0.92%	−8.80%	−16.84%

*Equals value of bond at a 9% yield to maturity minus value of bond at (the original) 8% yield, divided by the value at 8% yield.

11.1 Interest Rate Risk

- Macaulay's Duration
  - Measures effective bond maturity
  - Weighted average of the times until each payment, with weights proportional to the present value of payment
  - $w_t = \frac{CF_t/(1+y)^t}{Bond\ price}$
  - $D = \sum_{t=1}^{T} t \times w_t$

Spreadsheet 11.1 Calculation of Duration of Two Bonds

	A	B	C	D	E	F
1	Interest rate:	10%				
2						
3		Time until		Payment		Column (B)
4		Payment		Discounted		×
5		(Years)	Payment	at 10%	Weight*	Column (E)
6	**A. 8% coupon bond**	1	80	72.727	0.0765	0.0765
7		2	80	66.116	0.0696	0.1392
8		3	1080	811.420	0.8539	2.5617
9	Sum:			950.263	1.0000	2.7774
10						
11	**B. Zero-coupon bond**	1	0	0.000	0.0000	0.0000
12		2	0	0.000	0.0000	0.0000
13		3	1000	751.315	1.0000	3.0000
14	Sum:			751.315	1.0000	3.0000
15						
16	*Weight = Present value of each payment (column D) divided by bond price					

	A	B	C	D	E	F
1	Interest rate:	0.1				
2						
3		Time until		Payment		Column (B)
4		Payment		Discounted		×
5		(Years)	Payment	at 10%	Weight	Column (E)
6	**A. 8% coupon bond**	1	80	=C6/(1+$B$1)^B6	=D6/D$9	=E6*B6
7		2	80	=C7/(1+$B$1)^B7	=D7/D$9	=E7*B7
8		3	1080	=C8/(1+$B$1)^B8	=D8/D$9	=E8*B8
9	Sum:			=SUM(D6:D8)	=D9/D$9	=SUM(F6:F8)
10						
11	**B. Zero-coupon**	1	0	=C11/(1+$B$1)^B11	=D11/D$14	=E11*B11
12		2	0	=C12/(1+$B$1)^B12	=D12/D$14	=E12*B12
13		3	1000	=C13/(1+$B$1)^B13	=D13/D$14	=E13*B13
14	Sum:			=SUM(D11:D13)	=D14/D$14	=SUM(F11:F13)

11.1 Interest Rate Risk

- Change in Bond Price to Yield to Maturity
  - $\frac{\Delta P}{P} = D \times \left[\frac{\Delta(1+y)}{1+y}\right]$
- Modified Duration
  - $D^* = \frac{D}{1+y}$
  - $\frac{\Delta P}{P} = -D^* \, \Delta y$

Spreadsheet 11.2 Computing Duration

	A	B	C
1	**Inputs**		**Formula In column B**
2	Settlement date	1/1/2000	=DATE(2000,1,1)
3	Maturity date	1/1/2003	=DATE(2003,1,1)
4	Coupon rate	0.08	0.08
5	Yield to maturity	0.10	0.10
6	Coupons per year	1	1
7			
8	**Outputs**		
9	Macaulay duration	2.7774	=DURATION(B2,B3,B4,B5,B6)
10	Modified duration	2.5249	=MDURATION(B2,B3,B4,B5,B6)

11.1 Interest Rate Risk

- What Determines Duration?
  - Zero-coupon bond's duration is time to maturity
  - Time/yield to maturity constant, bond's duration and interest-rate sensitivity higher when coupon price lower
  - Coupon rate constant, bond's duration and interest-rate sensitivity generally increase with time to maturity; duration always increases with maturity for bonds at or above par

11.1 Interest Rate Risk

- What Determines Duration?
  - Other factors constant, duration and interest rate sensitivity of coupon bond higher when bond's yield to maturity lower
  - Duration of level of perpetuity:

$$\text{Duration of perpetuity} = \frac{1+y}{y}$$

Figure 11.2 Duration as Function of Maturity

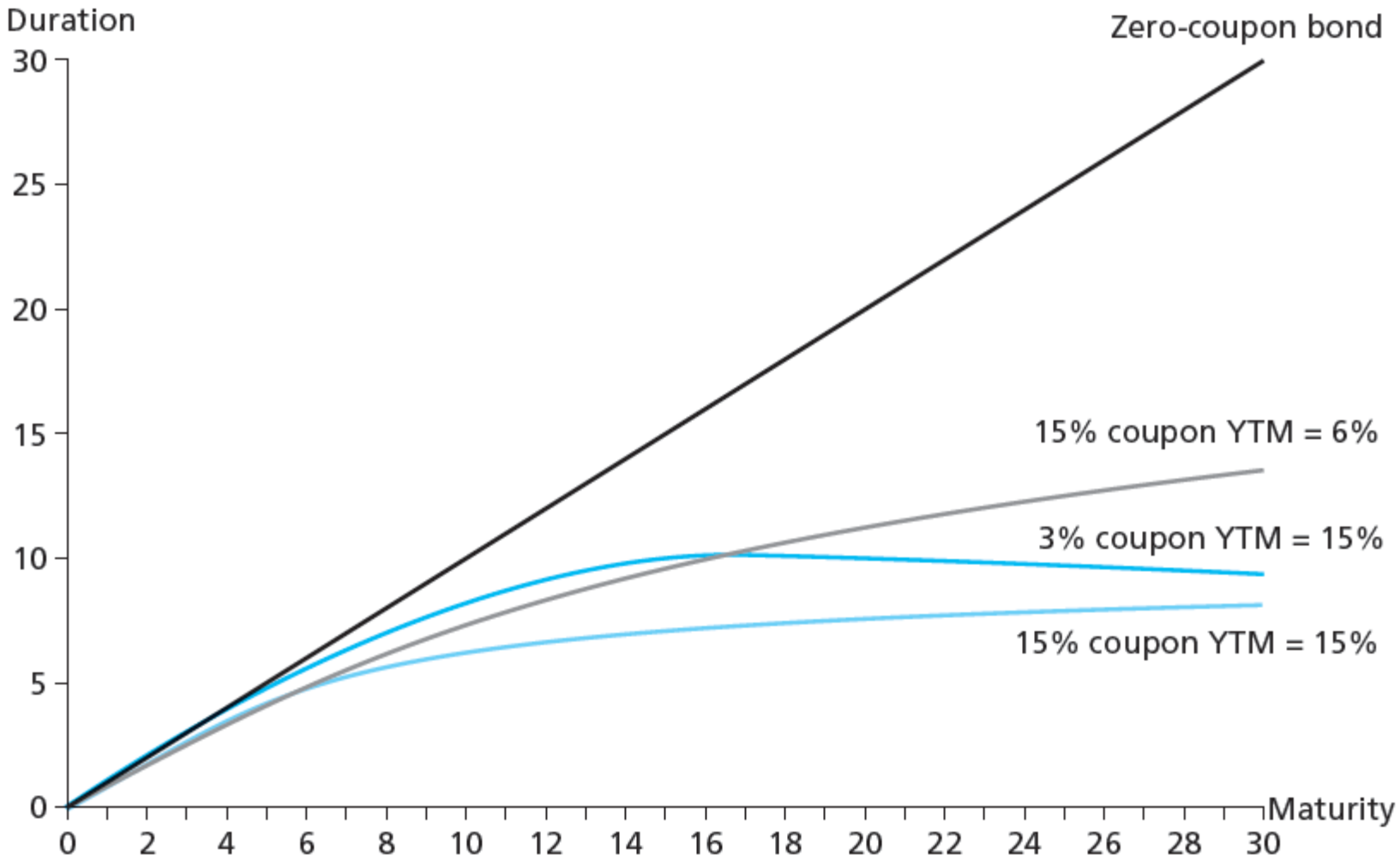


Table 11.3 Annual Coupon Bond Duration

Durations of annual coupon bonds (initial bond yield = 6%)				
	Coupon Rates (% per year)			
Years to Maturity	4%	6%	8%	10%
1	1.000	1.000	1.000	1.000
5	4.611	4.465	4.342	4.237
10	8.281	7.802	7.445	7.169
20	13.216	12.158	11.495	11.041
Infinite (perpetuity)	17.667	17.667	17.667	17.667

11.2 Passive Bond Management

- Immunization
  - Strategy to shield net worth from interest rate movements
- Rebalancing
  - Realigning proportions of assets in portfolio as needed

Table 11.4 Terminal Value of Bond Portfolio after Five Years

Payment Number	Years Remaining until Obligation	Accumulated Value of Invested Payment
A. Rates remain at 8%		
1	4	$800 \times (1.08)^4 =$ 1,088.39
2	3	$800 \times (1.08)^3 =$ 1,007.77
3	2	$800 \times (1.08)^2 =$ 933.12
4	1	$800 \times (1.08)^1 =$ 864.00
5	0	$800 \times (1.08)^0 =$ 800.00
Sale of bond	0	10,800/1.08 = 10,000.00
		14,693.28
B. Rates fall to 7%		
1	4	$800 \times (1.07)^4 =$ 1,048.64
2	3	$800 \times (1.07)^3 =$ 980.03
3	2	$800 \times (1.07)^2 =$ 915.92
4	1	$800 \times (1.07)^1 =$ 856.00
5	0	$800 \times (1.07)^0 =$ 800.00
Sale of bond	0	10,800/1.07 = 10,093.46
		14,694.05
C. Rates increase to 9%		
1	4	$800 \times (1.09)^4 =$ 1,129.27
2	3	$800 \times (1.09)^3 =$ 1,036.02
3	2	$800 \times (1.09)^2 =$ 950.48
4	1	$800 \times (1.09)^1 =$ 872.00
5	0	$800 \times (1.09)^0 =$ 800.00
Sale of bond	0	10,800/1.09 = 9,908.26
		14,696.02

Figure 11.3 Growth of Invested Funds

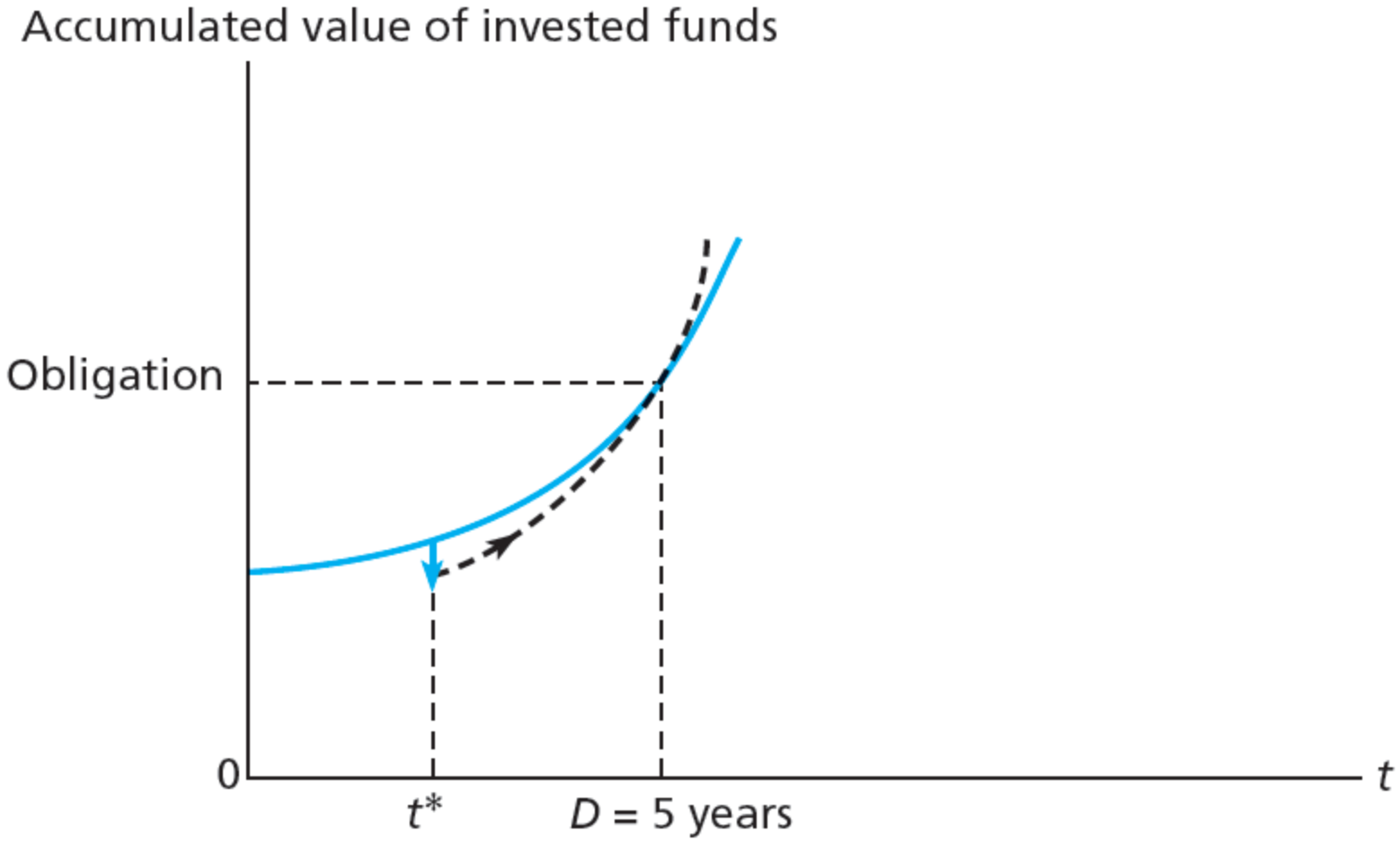


Table 11.5 Market Value Balance Sheets

A. Interest rate = 8%

Assets		Liabilities	
Bonds	$10,000	Obligation	$10,000

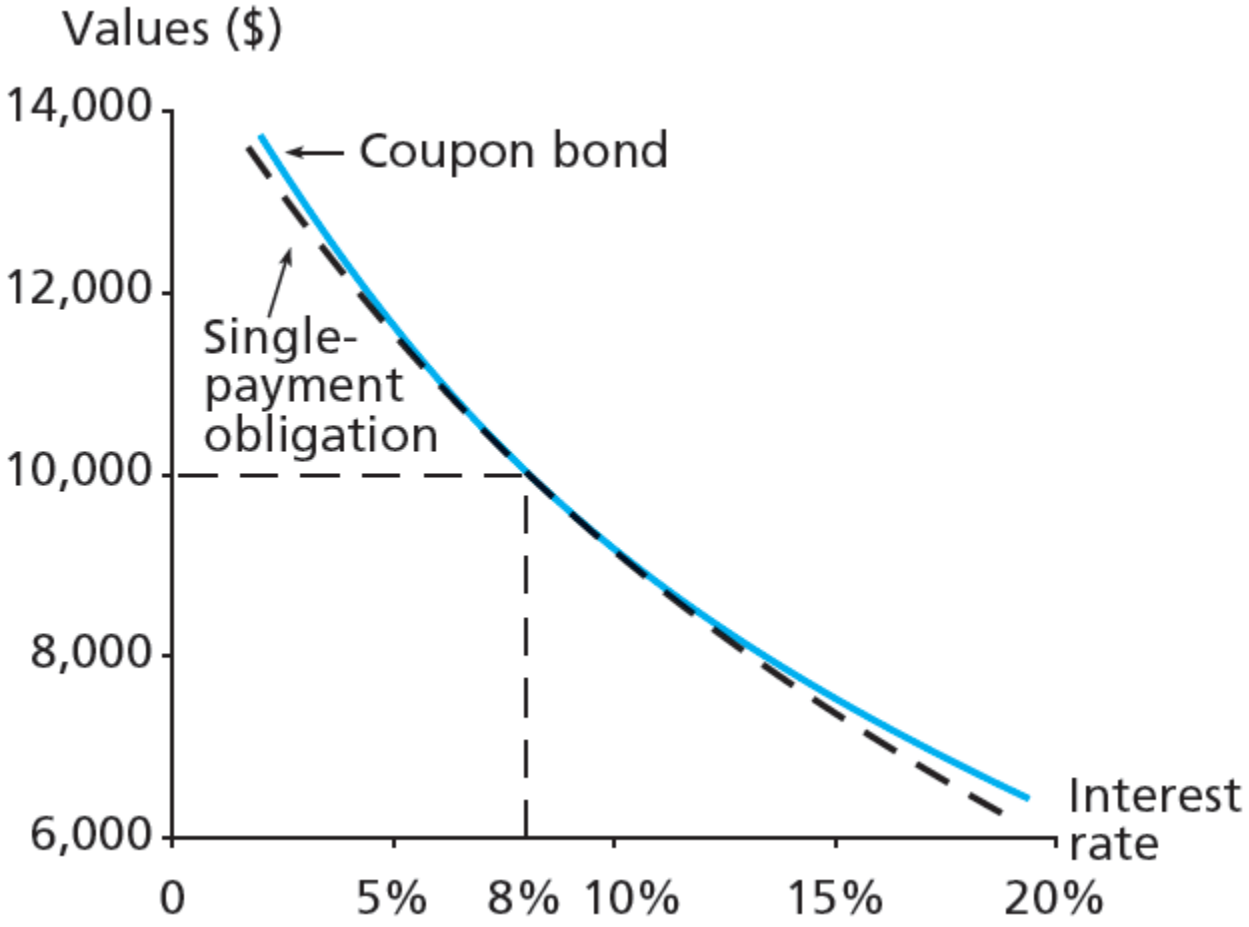
B. Interest rate = 7%

Assets		Liabilities	
Bonds	$10,476.65	Obligation	$10,476.11

C. Interest rate = 9%

Assets		Liabilities	
Bonds	$9,551.41	Obligation	$9,549.62

Figure 11.4 Immunization



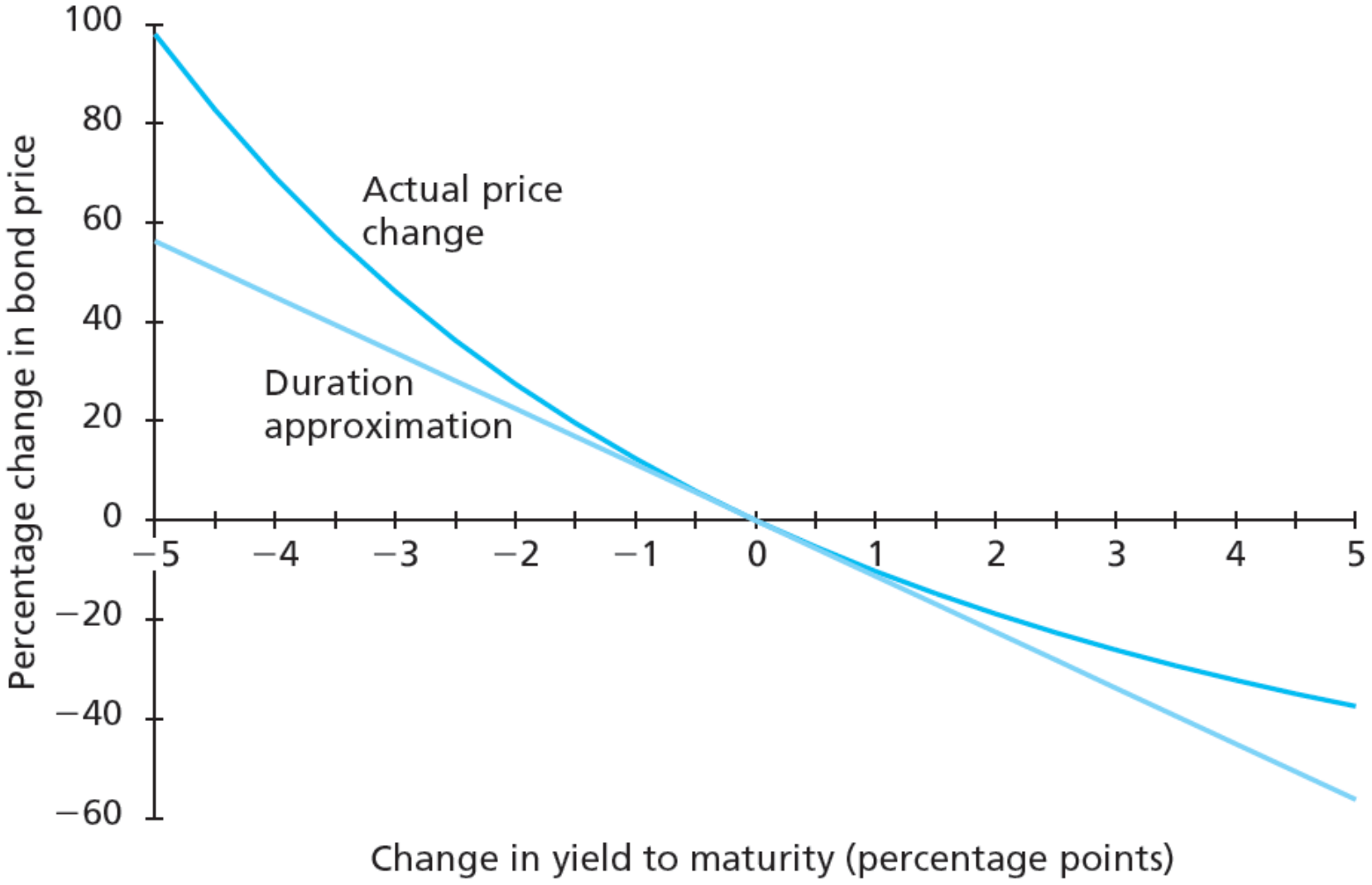
11.2 Passive Bond Management

- Cash Flow Matching and Deduction
  - Cash flow matching
    - Matching cash flows from fixed-income portfolio with those of obligation
  - Deduction strategy
    - Multi-period cash flow matching

11.3 Convexity

- Convexity
  - Curvature of price-yield relationship of bond
  - $\frac{\Delta P}{P} = -D^{*}\Delta y + {}^{1}/_{2} \times Convexity \times (\Delta y)^{2}$

Figure 11.5 Bond Price Convexity



11.3 Convexity

- Why Do Investors Like Convexity?
  - More convexity = greater price increases, smaller price decreases when interest rates fluctuate by larger amounts

11.4 Active Bond Management

- Sources of Potential Profit
  - Substitution swap
    - Exchange of one bond for bond with similar attributes and better price
  - Intermarket swap
    - Switching from one segment of bond market to another
  - Rate anticipation swap
    - Switch made in response to forecasts of interest rate changes

11.4 Active Bond Management

- Sources of Potential Profit
  - Pure yield pickup swap
    - Moving to higher yield bonds, usually with longer maturities
  - Tax swap
    - Swapping two similar bonds to receive tax benefit
  - Horizon analysis
    - Forecast of bond returns based largely on prediction of yield curve at end of investment horizon

11.4 Active Bond Management

- Example of Fixed-Income Investment Strategy
  - Key features
    - Firms respect market prices
    - To have value, information cannot already be reflected in prices
    - Interest rate movements extremely hard to predict